

## Unit Operations & Application of Microfluidic Systems for Remote Analysis

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Within the last decade the concepts of miniaturization have been seriously applied to chemical and biological problems. Of particular focus and interest has been the development and application of microfluidic or 'lab-on-a-chip technology'. These microscale analytical instruments employ micromachined features (such as channels, electrodes, reactors, and filters) and are able to manipulate fluid samples with high precision and efficiency. Microfluidic systems have been used in a wide variety of applications including nucleic acid separations, protein analysis, process control, small-molecule organic synthesis, DNA amplification, immunoassays, DNA sequencing, and cell manipulations. In a fundamental sense, chip-based analytical systems have been shown to have many advantages over their conventional (larger) analogues. These include improved efficiency with regard to sample size, response times, cost, analytical performance, process control, integration, throughput, and automation [1].

Much of the pioneering work in microfluidics has focused on the successful transfer of established analytical technologies from conventional to microfluidic (chip-based) formats. In particular, huge leaps in the efficiency and application of separation techniques have been facilitated by miniaturizing column dimensions and creating monolithic fluidic networks on planar substrates. Furthermore there is much current interest in using microfluidic systems for chemical and biological synthesis. Because of the unique environments afforded within microfluidic networks, a variety of synthetic processes can be performed in continuous flow and batch formats. Increased efficiencies of mixing and separation combined with high rates of thermal and mass transfer make microreactors ideal for processing valuable reaction components and improving reaction selectivities [2].

The idea that microfabricated analysis systems could be used in extraterrestrial environments is not new. The small size and low power requirements of the first silicon gas chromatograph fabricated by Stephen Terry at Stanford University in 1975 were seen at the time as ideal characteristics for better utilizing spacecraft resources. At a fundamental level, chip-based analysis systems possess many distinct advantages over their conventional counterparts for space flight purposes. These include improved performance, reduced instrumental footprints, reduced system masses, low power requirements, high levels of functional integration, built in redundancy (i.e. multiple devices per monolith), lack of moving parts and operational flexibility [3]

The paper will describe how we have used microfluidic devices to perform key unit operations within monolithic chip-based systems. Particular emphasis will be placed on component processes likely to be necessary for operation in extraterrestrial environments. These include sample pre-concentration [4], biomarker separation and highly miniaturized and integrated detection technologies [5]. It is hoped that the case studies presented will provide strong arguments for the use of microfluidic systems in future space missions.

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